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WOODEN DOORS

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The marked pick-up in residential building throughout the country has led to inquiries at the Forest Products Laboratory as to relative merits of various types of modern wooden doors. Most of the inquiries seek information on strength, the basis of this article, which should prove of great interest to door manufacturers and the trade alike.

In making a comparison of doors, it is necessary to consider the kind of strength properties or combination of properties essential to a satisfactory door. Failures in the glued joints of doors are more common than mechanical failures in the wood. It is therefore apparent that weathering, soaking or conditioning tests are often of greater value in determining the merits of a door than are mechanical tests. Moreover, the modern door is such a complex structure that the results obtained from mechanical tests on only one or two doors are of doubtful value and may even be quite misleading due to the tremendous influence of such factors as variability of the wood itself, type of glue used, workmanship in gluing, species of wood employed; and in the dowelled doors, relation of diameter of dowels to size of hole, moisture content of dowel, number of dowels, and design of door or dowel.

Several years ago tests were made at the Forest Products Laboratory to determine the superiority of doors of the through-mortised and tenoned, blind-mortised and tenoned, and dowelled types. A total of 72 doors were tested. The rails, stiles, and panels were of solid wood. Dowels were 1/2 inch in diameter and the tenons, both blind and through, were 5/8 inch thick. These tests indicated that the through-mortised and tenoned type of door possessed the highest structural strength and stiffness. The blind-mortised and tenoned doors showed the lowest maximum strength and resistance to swelling, although they showed a stiffness slightly greater than that of the dowelled doors. However, only one design of each type was tested, no attempt being made to vary structural details. It would, of course, be entirely possible to design a dowelled door or blind-mortised and tenoned door that would be as strong as a through-mortised and tenoned door by varying some of the structural details.

Assuming that the various members to be joined are uniformly at the correct moisture content for efficient gluing, one of the most important factors in the construction of doors is the gluing. If poor, improperly prepared, or insufficient glue is used, or its application is faulty, sagging of the doors and opening of the joints under stress are apt to result. When it is uncertain as to the exposure the doors are apt to encounter, it is safer to use a water-resistant type of glue. The gluing of the dowels is especially important in the dowelled door. Tests indicate that threaded dowels give quite consistent superiority in withdrawal resistance over smooth dowels. The threaded dowels tested were 5/8 inch in diameter and were of maple. They had a single spiral groove about 1/32 inch wide and about two-thirds as deep at a pitch of 4-1/2 turns per inch. They also had two longitudinal grooves on diametrically opposite sides. The longitudinal grooves were slightly under 1/16 inch wide at the surface of the dowel and were about 1/32 inch deep. The smooth dowels were simply smooth wooden pins 5/8 inch in diameter. After the tests, the door stiles were ripped through to enable inspection of the holes and the surface of the dowels.

Presumably the theory of the threaded dowel is that glue will be trapped in the grooves and will be carried along as the dowel is driven and not wiped away as is likely to be the case with smooth dowels. Examination showed, however, that at no point on any of the dowels was the spiral groove completely filled with glue, and in many instances glue did not reach the bottom of the grooves. The same is true of the longitudinal grooves except that sometimes they were filled with glue for 1/2 or 3/4 of an inch from the surface of the block into which they were driven. Small particles of wood adhered to the threaded dowels to a somewhat greater extent than they did to the smooth dowels. This indicated that the threaded dowels were somewhat more efficient in getting the glue to where it was needed and probably accounted for the higher shearing strength and withdrawal resistance obtained on dowels of this type.

The amount of wood adhering to the dowel, when pulled from the cross bars, however, was so small that it indicated that really good gluing, such as is readily obtained in joint work with the species used, had not been accomplished. Obviously this was due to the dowel not being completely surrounded with a film of glue when it reached its final position in the hole. It is believed that careful experiments would point out how much stronger and more durable dowelled joints could be made by proper control of other features of the gluing operation. Increase in the efficiency of dowelled joints would seem to be highly desirable. Too often the dowel in many factories has been looked upon merely as a fastening and not as an integral part of the door that requires special attention.

It seems very doubtful whether joints with as little glue as found in the foregoing tests would remain effective under the conditions of vibration and changes of moisture content to which doors are subjected in

service. It is understood that some door manufacturers apply glue to the walls of dowel holes by means of spindles operated by automatic machinery. The efficiency of the dowel joints produced in this manner is not known.

Shrinking and swelling with its attendant sticking is another trouble encountered in doors of all kinds. This is, of course, caused by moisture changes in the door itself and may be greatly retarded by proper seasoning and painting. Warp, which includes bow, cup, twist, and crook, may come from unequal moisture content values in the various component pieces at the time of gluing, or from purely mechanical defects. Lack of refinement in the manufacture of the door, such as poor matching of veneer, is a common cause of warp. A cross band of a slab door, laid with its grain at a pronounced angle with that of its mate, is likely, for instance, to pull a slab door all out of shape. It is therefore well to store a new door for several weeks before hanging under conditions as nearly as possible like those under which it is to be used in order to allow it to reach a moisture content approximating that of actual use. After all fitting is done, it should be finished all over and especially on the top and bottom edges. Thorough finishing will retard the excessive moisture changes which may cause swelling or warping of the door.

The moisture content correct for the service to which a door is to be put of course varies with conditions, which for example are not the same in a bungalow on the Gulf of Mexico as they are in a steam-heated apartment in Minnesota. Where the exact conditions are known they should govern; seasonal changes naturally require the use of average figures.

A study has been made at the Forest Products Laboratory to determine the changes that occur in the dimension of doors made from lumber of different moisture content values. The results are by no means intended to indicate proper or improper moisture values, but rather are intended merely to show what happens in one representative type of door when, for example, sample doors are made up from lumber at 9, 12, and 16 percent moisture content values, respectively, and are hung in rooms in which the atmospheric conditions simulate those inside a home in the northern states.

Six three-panel doors were used in this study. The wood was air dried ponderosa pine of quality suitable for a No. 2 grade of door. The stiles and rails were held together with oak dowels at each joint, two in the top rail, three in the middle, and four in the bottom, which is a total of nine to a stile.

The finished doors were hung on hinges in the usual manner, three of them in a room where the relative humidity and the temperature were held constant at the summer values of 60 percent and 80° F. respectively, and three in a room where the winter conditions of 30 percent and 80° F. were maintained. Measurements and weighings were then made periodically to determine twisting, cupping, and changes in sizes and weight.

The doors made up from lumber of 9, 12, and 16 percent moisture content, developed openings at the muntin and shrank noticeably in the panels when subjected to conditions similar to those in a residence in a northern state in winter. The opening in the 16 percent door was very noticeable, that in the 12 percent door less so, and that in the 9 percent door still less. Changes in dimension of the doors, called working, upon transfer from conditions approximating summer in the northern states to those approximating winter in the same region were practically the same as the converse changes. Changes in dimension were greater than twisting and cupping changes. Only a small amount of twisting took place even in the upper part of the doors, where the low stiffness permitted the maximum amount. The cupping took place nearest the unhinged side of the door. The change in width of the rails was not so great at the ends as at the midpoints, because the dowels restrained shrinkage at the ends.

The kind of wood generally used for core stock in veneered panel doors is one of light weight and low shrinkage. The species most commonly used are white pine and ponderosa pine. Little information is available on the best thickness of veneer to use for stiles and rails. The experience at the Forest Products Laboratory has been that less face checking results when the veneer is thin, than when it is thick. Veneer as thick as 1/4 inch is very likely to check on drying. The thicker the veneer the greater the difficulty from shrinking and swelling due to moisture changes, particularly in cases where no cross banding is used. Tests fail to show any appreciable difference between sliced, sawed, and rotary-cut veneers when made into plywood. There is a slight advantage in the plywood made of sawed veneer in that the plies are all practically quarter-sawed material and lend themselves to a minimum of twisting and warping with shrinkage. Sawed veneer also has less tendency to check and split under severe exposure conditions. For the same reason, vertical grained veneer can probably be dried with less trouble from splitting and curling.

With proper gluing little difficulty should be experienced with either sliced, rotary-cut, or sawed veneer. They can all be glued successfully. It would be difficult to state which would give the best panel in three or five-ply construction.

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